

# The hermit crabs (Decapoda: Anomura: Diogenidae, Paguridae) of southwestern Australia, with descriptions of two new species

Gary J. Morgan\*

## Abstract

Fifteen species of diogenid and two species of pagurid hermit crabs are recorded from the intertidal and subtidal marine habitats of southern and southwestern Western Australia. A key to their identification is provided. Live coloration of several species is described for the first time. Two new species, *Calcinus dapsiles* and *Diogenes lophochir*, are described and figured. *C. dapsiles* is the most common hermit crab of this region.

## Introduction

The hermit crab fauna of Australia has been poorly documented and in particular the species of the southwestern coast have received scant attention. Except for a review of the genus *Paguristes* (Morgan 1987a), there have been no reports of the hermit crab species except for incidental mention in more general publications (e.g. McCulloch 1913; 'paguroid' spp. in Black and Prince 1983).

The present paper records the hermit crabs, families Diogenidae and Paguridae, of the coast from Esperance (35°52'S, 121°53'E) in the east to Geraldton (28°46'S, 114°37'E) in the northwest. This area has been extensively sampled by the author using SCUBA, snorkelling and by hand, and this report is based upon those collections together with holdings in the Western Australian Museum (WAM). A new species of *Diogenes* and of *Calcinus* are described. The exclusively deepwater family Parapaguridae is not considered here.

Shield length of specimens is abbreviated as SL and carapace length as CL. Australian states are abbreviated in distributions as follows: Western Australia (W.A.), South Australia (S.A.), Tasmania (Tas.), Victoria (Vic.) and New South Wales (N.S.W.).

The diversity and biogeographic affinities of the hermit crab fauna of the southwest coast are discussed. The Houtman Abrolhos Islands, lying 60 km west of Geraldton, display an unusually high proportion of tropical faunas (Montgomery 1931) and are regarded here as biogeographically distinct from the southwest Australian coast. The Houtman Abrolhos will be considered in future revisions of tropical hermit crab faunas.

## Systematics

### Key to Genera and Species of Southwestern Australian Hermit Crabs.

1. Third maxillipeds approximate at bases; chelipeds  
subequal or left larger than right ..... Diogenidae 2

\* Department of Carcinology, Western Australian Museum, Francis Street, Perth, Western Australia 6000.

- Third maxillipeds widely separated at bases; right  
cheliped much larger than left ..... Paguridae 16
2. Male with paired first and second pleopods, female with  
paired first pleopods ..... *Paguristes* 3  
Paired pleopods absent in both sexes or second pair only  
paired on male ..... 7
3. Chelipeds subequal ..... 4  
Left cheliped obviously larger than right ..... 5
4. Setae on chelipeds very long but not obscuring spines  
..... *Paguristes longisetosus* Morgan  
Setae on chelipeds moderately long and very dense,  
obscuring spines ..... *Paguristes sulcatus* Baker
5. Rostrum short, not exceeding lateral projections; left  
cheliped with spines ..... *Paguristes tuberculatus* Whitelegge  
Rostrum long, much exceeding lateral projections; left  
cheliped finely tuberculate ..... 6
6. Dactyl of right cheliped with irregularly sized tubercles  
and spines; pereopods salmon with scattered red spots,  
antennae red-orange ..... *Paguristes frontalis* (H. Milne Edwards)  
Dactyl of right cheliped with dense, similarly sized  
tubercles; pereopods cream-orange with dense red  
speckles, antennae purple ..... *Paguristes purpureantennatus* Morgan
7. Moveable rostral spine between ocular peduncles ..... *Diogenes* 8  
No moveable rostral spine ..... 9
8. Ocular peduncles shorter than antennal peduncles .... *D. lophochir* sp. nov.  
Ocular peduncles longer than antennal peduncles ..... *D. serenei* Forest
9. Chelipeds forming operculum; abdomen and uropods  
symmetrical; male lacking pleopods ..... *Cancellus* sp.  
Chelipeds not forming operculum; abdomen and uropods  
asymmetrical; male with pleopods ..... 10
10. Cheliped fingers moving horizontally; (live coloration  
predominantly green, green-brown or green-blue)  
..... *Clibanarius virescens* (Krauss)  
Cheliped fingers moving obliquely ..... 11
11. Propodus and carpus of chelipeds bearing stridulatory  
ridges; male with paired pleopods on second abdominal  
segment ..... *Trizopagurus strigimanus* (White)  
No stridulatory ridges on chelipeds; no paired pleopods in  
either sex ..... 12

12. Ocular acicles large and broad; carpus of left cheliped with numerous spines on upper surface; tips of fingers corneous .... *Dardanus* 13  
 Ocular acicles slender; carpus of left cheliped with prominent tubercle on upper surface; tips of fingers calcareous ..... *Calcinus* 15
13. Chelipeds and second and third pereopods with outer faces ornamented with transverse striae fringed by short setae ..... *Dardanus arrosor* (Herbst)  
 No transverse striae on chelipeds ..... 14
14. Left cheliped distinctly larger than right; dactyl and propodus of third left pereopod distinctly flattened laterally and tessellated ..... *Dardanus crassimanus* (H. Milne Edwards)  
 Chelipeds subequal; dactyl and propodus of third left pereopod not obviously flattened laterally ..... *Dardanus* sp.
15. Several marginal spines on left posterior lobe of telson; dactyl of pereopods 2 and 3 with short longitudinal stripes of dark red-blue proximally ..... *Calcinus latens* (Randall)  
 One marginal spine on left posterior lobe of telson; dactyl of pereopods 2 and 3 uniformly pink proximally... *Calcinus dapsiles* sp. nov.
16. Right cheliped densely covered in short plumose setae; male lacking long setae around right gonopore.... *Pagurus sinuatus* (Stimpson)  
 Right cheliped naked; male with long setae around right gonopore directed towards left side  
 ..... *Pagurixus jerviensis* McLaughlin and Haig

## Diogenidae

### *Paguristes longisetosus* Morgan

*Paguristes longisetosus* Morgan, 1987a: 726, Fig. 1.

#### Holotype

♂, SL 7.3 mm, Two Mile Beach, east of Hopetoun, W.A., rocks, shallow sublittoral, 28 November 1985, WAM 1441-86.

#### Paratypes

2 ♂♂, SL 7.3 mm, 5.0 mm, 1 juv. in shell, type locality, 28 November 1985, WAM 1442-86; 2 ♂♂, SL 4.9 mm, 2.4 mm, 2 ♀♀, SL 4.3 mm (ovig.), 2.3 mm, 1 juv., Frenchmans Bay, south of Albany, W.A., shallow sublittoral rocks and sand, 19 April 1986, WAM 1443-86.

#### Other material

♂, SL 2.8 mm, 3 ♀♀, SL 3.7 mm, 2.9 mm, 2.9 mm, Cheyne Beach, east of Albany, W.A., rocks, 1 m, 21 January 1988, WAM 139-88; 15 specs, SL 5.5 mm-3.5 mm, Quaranup, south of Albany, W.A., sand and *Posidonia*, 0.5 m, January 1988, WAM 446-88; 2 ♂♂, SL 5.6 mm, 3.9 mm, ♀, SL 4.3 mm, Quaranup, near jetty, 0.5 m, 14 January 1988, WAM 163-88; ♂, SL 4.3 mm, ♀, SL 2.9 mm, Princess Royal Harbour, Albany, W.A., 26 January 1988, WAM 137-88.

## Remarks

Morphology and coloration of this species are described by Morgan (1987a). *P. longisetosus* is readily recognised by its long setae and acute spines on the chelipeds. It has been collected from shells of *Thais orbita* (Gmelin, 1791), *Nerita atramentosa* Reeve, 1855, *Cominella eburnea* (Reeve, 1846), *Phasianella ventricosa* Swainson, 1822, *Thalotia conica* (Gray, 1827), *Austrocochlea constricta* (Lamarck, 1822), *Bittium granarium* (Kiener, 1842), *Zeacumantus diemenensis* (Quoy and Gaimard, 1834) and *Nassarius pyrrhus* (Menke, 1843).

## Distribution

Southwestern Australian endemic, known only from Hopetoun to Albany, W.A.

## *Paguristes sulcatus* Baker

*Paguristes sulcatus* Baker, 1905: 258, pl. 34 fig. 1, 1a; McCulloch, 1913: 346 (key); Hale, 1927: 90, fig. 85 (after Baker).

## Material examined

♂, SL 3.7 mm, ♀, SL 3.0 mm, Lucky Bay, Cape Le Grand N.P., near Esperance, W.A., rocks, 1-2 m, 27 November 1985, WAM 205-88; 3 ♂♂, SL 14.5 mm, 14.1 mm, 9.1 mm, ♀, SL 4.5 mm, Little Bay in Two Peoples Bay, east of Albany, W.A., 2-3 m, 18 April 1986, WAM 198-88; 9 specs, SL 16.5 mm-7.7 mm (incl. ovig. ♀, SL 8.9 mm), Ledge Point, near Gull Rock, King George Sound, W.A., rocks, 2-3 m, 16 April 1986, WAM 199-88; 2 ♂♂, SL 16.3 mm, 16.1 mm, ♀, SL 11.4 mm, west side of Cape Vancouver, near Albany, W.A., rock, 25 m, 17 April 1986, WAM 203-88; 5 ♂♂, SL 9.0 mm - 4.6 mm, 2 ♀♀, SL 5.3 mm, 5.2 mm, Frenchmans Bay, old whaling station, south of Albany, W.A., sand and seagrass, 1.5 m, 19 April 1986, WAM 206-88; 5 ♂♂, SL 14.6 mm-9.4 mm, 2 ♀♀ (ovig.), SL 12.1 mm, 9.4 mm, inside Mistaken I., King George Sound, W.A., rocks, 2-3 m, 3 December 1985, WAM 200-88; 2 ♀♀, SL 14.4 mm, 3.8 mm, inside Shelter I., west of Albany, W.A., 1 December 1985, WAM 201-88; 2 ♂♂, SL 13.1 mm, 9.8 mm, Canal Rocks, south of Yallingup, W.A., rocks, 2 m, 6 December 1985, WAM 202-88; 2 ♂♂, SL 13.8 mm, 9.9 mm, ♀ (ovig.), SL 12.2 mm, Cottesloe Beach, Perth, W.A., rocky reef slope, 2-4 m, 16 January 1986, WAM 196-88; 2 ♂♂, SL 16.6 mm, 6.1 mm, ♀ (ovig.), SL 12.6 mm, Geordie Bay, Rottnest I., W.A., 18 December 1985, WAM 492-86; 2 ♂♂, SL 10.2 mm, 6.7 mm, 2 ♀♀, SL 5.3 mm, 2.4 mm, Cliff Head, south of Dongara, W.A., sand and mixed seagrasses, 1 m, 23 April 1986, WAM 197-88; ♂, SL 2.8 mm, Seven Mile Beach, north of Dongara, W.A., 1 m, 22 April 1986, WAM 204-88.

## Coloration (in life)

Shield cream and brown mottled. Ocular peduncles pale brown, white near corneas; acicles cream or pale brown; corneas black. Antennular peduncles deep brown-grey with cream near articulations; flagella deep grey-blue. Antennal peduncles cream and brown; flagella distinctly banded in brown and cream, usually with alternating wide and narrow brown annuli. Cheliped colours largely obscured by dense setae; all segments primarily pale to medium brown; prominent spines cream or white basally with dark brown corneous tips. Pereiopods 2 and 3 pale brown and cream; pereiopods 4 and 5 very pale. Setae brown.

## Remarks

*Paguristes sulcatus* is a common hermit crab of southern Australia, having previously been recorded from South Australia (Baker 1905; Hale 1927; Mower and Shepherd

1988) and southern Western Australia (Morgan 1987a). It occurs in littoral and sublittoral waters to at least 25 m depth, and is usually associated with rock or rock-sand habitats. Mower and Shepherd (1988) noted densities of *P. sulcatus* in excess of 10 per m<sup>2</sup> in South Australia.

Specimens examined agree quite well with the original description of Baker (1905) with some minor qualifications. On the Western Australian specimens, the antennular peduncles are usually slightly longer, rather than shorter, than the ocular peduncles. There are frequently four spines on ocular acicles. Baker (1905) did not describe or illustrate the first pleopod of males which is here figured (Figure 1a) for comparison with other southern Australian congeners. Baker also did not note the shape or size of the female brood pouch which is sub-elliptical and large, covering the anterior half of the abdomen. The live colours of the species are here described for the first time.

Examined specimens inhabited shells of *Thais orbita* (Gmelin, 1791), *Turbo torquatus* Gmelin, 1790, *T. intercostalis* Menke, 1843, *Campanile symbolicum* Iredale, 1917, *Astrarium squamifera* (Koch, 1844), *Austrocochlea rudis* (Gray, 1827), *Phasianella australis* (Gmelin, 1788), *Fusinus australis* (Quoy and Gaimard, 1833), *Thalotia conica* (Gray, 1827), *Phalium pauciruge* (Menke, 1843) and *Cabestana* sp.

A large (SL 13.1 mm) male (WAM 201-88) from Canal Rocks is unusual in its poor development of the 1st and 2nd pair of pleopods. The first pair are merely undifferentiated lobes produced from the abdomen and the 2nd pleopod is only a minute lobule on the left side and totally absent on the right. The gonopores are also smaller than on other similarly sized males and it is doubtful that this is a fully functional male. There are, however, no female pores.

### Distribution

A southern Australian endemic, from South Australia to Geraldton, W.A.

### *Paguristes tuberculatus* Whitelegge

*Paguristes tuberculatus* Whitelegge, 1900: 169, fig. 11, 11a; McCulloch, 1913: 343, fig. 51; Hale, 1927: 90.

### Material examined

31 specs, SL 4.1 mm-1.9 mm, (incl. 10 ovig. ♀♀, SL 3.4 mm-2.2 mm), Whaling Cove, King George Sound, W.A., sand and *Posidonia*, 2-3 m, 16 January 1988, WAM 142-88, 161-88; 2 ♂♂, SL 3.3 mm, 3.2 mm, 2 ♀♀, SL 2.8 mm, 2.4 mm, Quaranup, south of Albany, W.A., sand, 15 January 1988, WAM 162-88; 4 ♂♂, SL 3.2 mm-2.1 mm, 2 km southwest of Geak Pt, Princess Royal Harbour, W.A., *Posidonia*, 16 January 1988, WAM 129-88; 34 specs, SL 3.4 mm-1.5 mm, Barker Bay, King George Sound, W.A., *Posidonia* and sand, 4 m, 16 January 1988, WAM 144-88; ♂, SL 3.4 mm, King George Sound, W.A., 14 January 1988, WAM 148-88; ♂, SL 4.3 mm, west of Swanbourne, Perth, W.A., 12 October 1976, WAM 1654-86.

### Remarks

A relatively small species, *P. tuberculatus* is common in shallow sublittoral, often estuarine waters of southeastern Australia, to depths of at least 50 m. In Western Australia, the species has been collected from soft substrates, usually associated with *Posidonia* seagrass meadows.



Examined specimens generally agree well with the description and figures of Whitelegge (1900) and figure of McCulloch (1913). One notable exception is that the left chela is rather more setose than described or illustrated in the above papers. The upper and lower margins of the fingers and palm are fringed with long, dense plumose setae, which also form scattered clumps on the external face of the palm, usually emanating from the bases of the compound tubercles.

The male first pleopod of *P. tuberculatus* has not been figured and is here illustrated (Figure 1b).

Whitelegge (1900) noted the colour of *P. tuberculatus* as 'outer antennae and walking legs annulated with narrow reddish bands. Chelae bright red, tips of fingers of larger hand white, body and limbs scantily clothed with brownish hairs'. Live colours were not recorded for the present study.

Shells occupied by observed Western Australian specimens were *Cominella eburnea* (Reeve, 1846), *Nassarius pyrrhus* (Menke, 1843), *Polinices conicus* (Lamarck, 1822), *Thalotia conica* (Gray, 1827), *Fusinus australis* (Quoy and Gaimard, 1833) and *Bittium granarium* (Kiener, 1842).

McCulloch (1913) noted that *P. tuberculatus* usually had a colony of Bryozoa (? *Cellepora* sp.) attached to the shell and suggested that the relationship was 'not accidental'. Hale (1927) recorded similar growths on some shells occupied by the species in South Australia. Bryozoa were not obvious epizoids on the shells of Western Australian specimens examined.

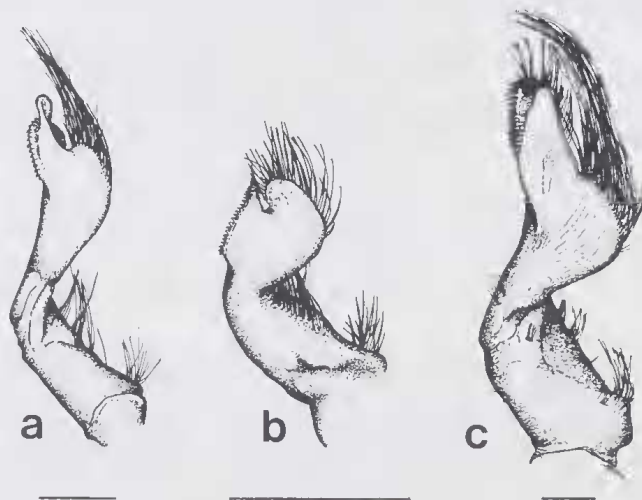


Figure 1. Left first pleopod of male, lateral view. (a) *Paguristes sulcatus*, SL 16.5 mm; (b) *P. tuberculatus*, SL 4.1 mm; (c) *P. frontalis*, SL 24.5 mm. Scales = 1.0 mm.

## Distribution

Southern Australian endemic, from the region of Port Macquarie, N.S.W., south to Hobart, Tas., and west through S.A. to Albany, (previously recorded by McCulloch 1913) and now known as far west and north as Perth, W.A.

## *Paguristes frontalis* (H. Milne Edwards)

*Pagurus frontalis* H. Milne Edwards, 1836: 283, pl. 13 fig. 3.

*Eupagurus frontalis* - Haswell, 1882: 154.

*Paguristes frontalis* - Alcock, 1905: 155; Baker, 1905: 252, pl. 32 figs 1-7; McCulloch, 1913: 345 (key); Hale, 1927: 89, fig. 84; Phillips *et al.*, 1984: 110; Morgan, 1987a: 732, fig. 3B.

### Material examined

13 specs, SL 24.5 mm-3.0 mm, Two Mile Beach, east of Hopetoun, W.A., rocks, 2-4 m, 28 November 1985, WAM 212-88; 2 ♂♂, SL 12.1 mm, 11.3 mm, 3 ♀♀, SL 9.4 mm, 8.2 mm, 5.7 mm, Barren Beach, Fitzgerald River N.P., W.A., sand and rock, 1-2 m, 29 November 1985, WAM 213-88; ♂, SL 15.9 mm, ♀, SL 20.5 mm, Little Bay in Two Peoples Bay, east of Albany, W.A., 2 m, 18 April 1986, WAM 210-88; ♂, SL 22.5 mm, Frenchmans Bay, old whaling station, south of Albany, W.A., 19 April 1986, WAM 209-88; ♀, SL 8.1 mm, Quaranup near jetty, south of Albany, W.A., rocks, 1 m, 14 January 1988, WAM 214-88; 15 specs, SL 13.9 mm-1.3 mm, Quaranup, rocks, 0.5-1.5 m, January 1988, WAM 449-88; ♀, SL 18.2 mm (with juveniles), Bunker Bay, east of Cape Naturaliste, W.A., rocks, 1 m, 6 December 1985, WAM 211-88.

### Coloration (in life)

Shield deep salmon-brown. Ocular peduncles deep red-brown or salmon-brown, with bright orange band immediately proximal to corneas; ocular acicles salmon-brown. Antennules and antennae salmon-brown. Dactyl of chelipeds cream, sometimes with a salmon tinge; propodus cream with some salmon proximally; carpus cream and salmon-brown; merus salmon-brown. Pereiopods 2 and 3 salmon-brown, distal segments usually paler; dark corneous spines, especially on dactyl; scattered red or red-brown spots at setal pores. Pereiopods 4 and 5 pale salmon-brown with scattered red spots. Setae pale orange.

### Remarks

*Paguristes frontalis* is a very large, brightly coloured hermit crab, common in southern Australian inshore waters. Coloration was only briefly noted by Milne Edwards (1836) and translated by Haswell (1882) as 'reddish, livid; a few yellowish hairs on the hand and the sides of the carapace'. Baker (1905) included some colour notes scattered throughout his redescription of the species but these are difficult to interpret as an overall colour description. Live coloration is an important character distinguishing the species from *P. purpureantennatus* and is recorded in detail above.

Baker (1905) included a figure of the first male pleopod (Pl. 32 fig. 7) but its orientation is slightly different from and hence is not easily compared to the pleopods of other species of *Paguristes* illustrated in this paper and by Morgan (1987a). Therefore, the first pleopod of *P. frontalis* is illustrated here (Figure 1c).

The characters distinguishing this species from *P. purpureantennatus* were discussed by Morgan (1987a). The ranges of the two species overlap at least from Albany to Cape Naturaliste.

Most of the large specimens from Western Australia examined inhabited shells of *Campanile symbolicum* Iredale, 1917, but smaller specimens utilised shells of *Austrocochlea rudis* (Grey, 1827), *Thais orbita* (Gmelin, 1791), *Phasianella australis* (Gmelin, 1788) and *Mitra* sp. *P. frontalis* displays abbreviated larval development as described by Morgan (1987c).

## Distribution

Southern Australian endemic, from Vic. west of Wilsons Promontory, S.A. and W.A. as far north as Cape Naturaliste.

## *Paguristes purpureantennatus* Morgan

*Paguristes purpureantennatus* Morgan, 1987a: 729, figs 2, 3A.

### Holotype

♂, SL 21.2 mm, CL 33.3 mm, Cosy Corner, near Migo Island, Torbay, west of Albany, W.A., rocks and sand near *Amphibolis* and *Posidonia* seagrasses, 3 m, 1 December 1985, WAM 1438-86.

### Paratypes

♂, SL 22.2 mm, 3 ♀♀, SL 19.0 mm (ovig.), 15.6 mm, 15.6 mm, near Dyer Island, Rottnest Island, W.A., rock and sand, 3-4 m, 19 December 1985, WAM 493-86; 2 ♀♀, SL 14.8 mm, 12.9 mm (both ovig.), Geordie Bay, Rottnest Island, W.A., rock and sand, 6 m, 18 December 1985, WAM 405-86; 2 ♂♂, SL 10.9 mm, 10.2 mm, offshore from Rottnest Island hotel, W.A., rock and sand, 6 m, 19 December 1985, WAM 403-86; ♀, SL 18.2 mm (ovig.), Parker Point, Rottnest Island, W.A., sand, rock and *Pocillopora* coral, 3 m, 19 December 1985, WAM 500-86; 2 ♂♂, SL 9.5 mm, 3.8 mm, 1 juv., Cliff Head, south of Dongara, W.A., sand and rock near seagrasses, 2-3 m, 23 April 1986, WAM 1440-86; ♀, SL 4.5 mm, 4 juvs, Seven Mile Beach, north of Dongara, W.A., sand and rock, 1-3 m, 22 April 1986, WAM 1439-86.

### Other material

♀, SL 15.6 mm (ovig.), Frenchmans Bay, south of Albany, W.A., littoral, 20 January 1988, WAM 450-88; ♀ (ovig.), SL 13.6 mm, Cockburn Sound, W.A., 4 August 1970, WAM 827-86; 2 ♀♀, SL 14.6 mm (ovig.), 14.0 mm, 0.5 miles southwest of Thirsty Point, near Cervantes, W.A., sand, rock and seagrasses, 2-3 m, 29 April 1987, WAM 345-88; ♂, SL 14.6 mm, 2 ♀♀, SL 11.1 mm (ovig.), 9.4 mm, Geraldton, W.A., littoral, September 1987, WAM 189-88.

### Remarks

Live coloration of *P. purpureantennatus* was described by Morgan (1987a). The species closely resembles *P. frontalis* (H. Milne Edwards) but can be distinguished by cheliped and colour characteristics (Morgan 1987a). Morgan commented on the overlap in ranges of the two species but observed that they had not been collected from the same locality. Recently, a specimen of *P. purpureantennatus* (WAM 450-88) was collected from Frenchmans Bay south of Albany, where *P. frontalis* had been previously found (WAM 209-88).

Large specimens of *P. purpureantennatus* show preference for large shells of *Campanile symbolicum* Iredale, 1917, but smaller specimens have been collected from a range of shells including *Rhinoclavis bituberculatum* (Sowerby, 1855).

## Distribution

Southwestern Australian endemic, from Albany in the east to Geraldton in the northwest.

## *Diogenes lophochir* sp. nov.

Figure 2

### Holotype

♂, SL 3.9 mm, CL 7.6 mm, northeast of Rottnest I., W.A., 34 m, 18 September 1965, WAM 398-86.



### Paratype

♂, SL 3.4 mm, northeast of Rottneest I., W. A., 32 m, from naticid shell, 18 September 1965, WAM 394-86; 1 left cheliped, type locality, WAM 398-86 (part).

### Diagnosis

A species of *Diogenes* differing from *D. costatus* Henderson, 1893 in having antennular and antennal peduncles of similar length; non-deflexed fixed finger on left chela and lower margin of chela tuberculate for entire length; carpus and propodus of third pereopods spinose along entire dorsal borders.

### Description

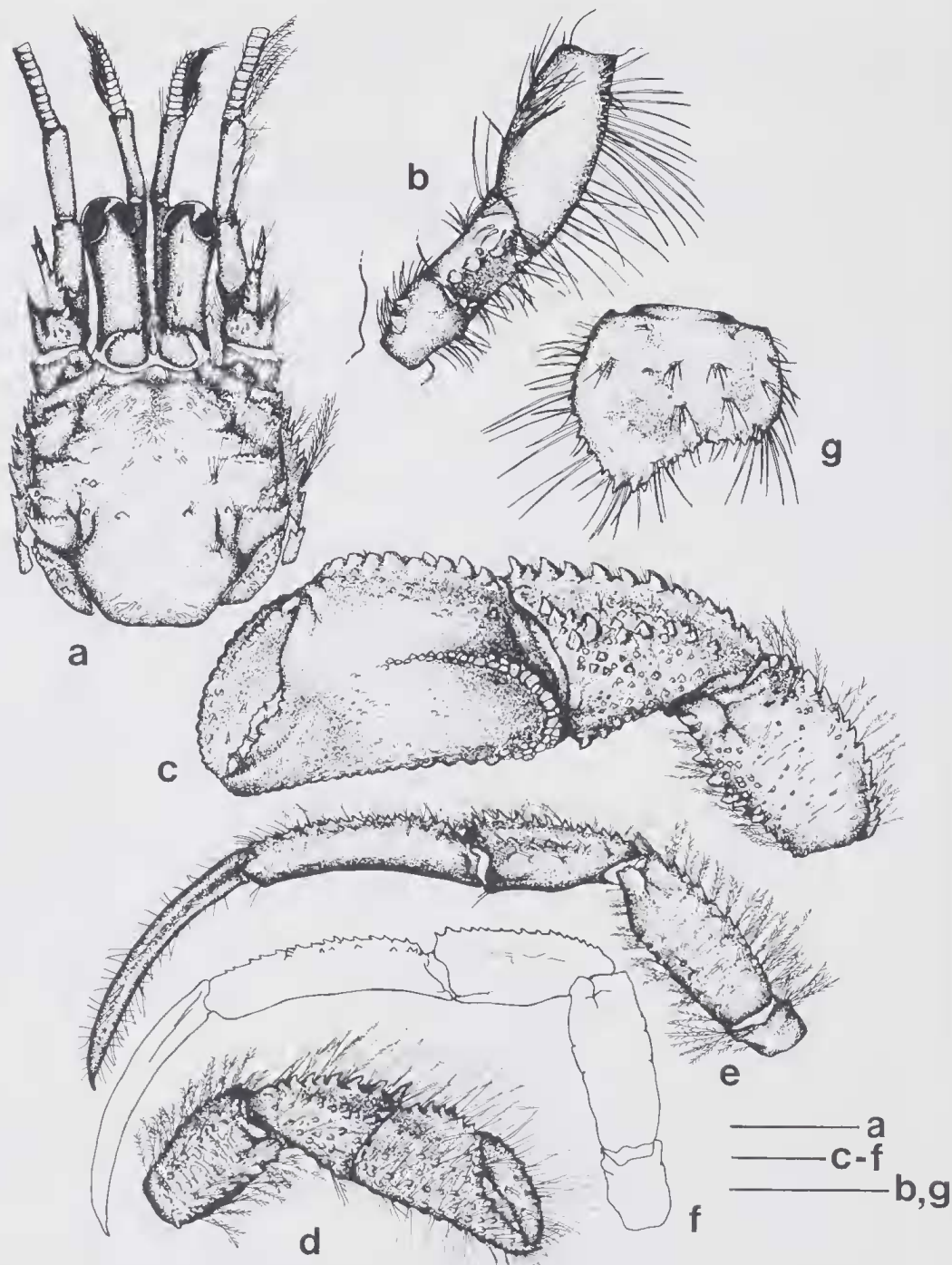
Shield (Figure 2a) almost as broad as long. Lateral margins almost straight, with numerous spines in short rows; lateral surfaces with 6-7 large curved spines in row along entire dorsal margin. Anterior margin between rostrum and lateral projections concave; rostrum broad and very short, exceeded by lateral projections. Lateral projections triangular, with several marginal spinules. Shield with scattered simple setae dorsally, longer weakly plumose setae laterally.

Ocular peduncles cylindrical, shorter than or just reaching base of ultimate segment of antennular peduncles, slightly inflated distally, much shorter than anterior margin of shield. Ocular acicles with distal 2/3 of anterior margin spinose, largest spines apical; acicles anterolaterally convex, almost straight mesially; separated at bases by about 1/3 of width of one acicle. Intercalary rostral process simple, slightly shorter than acicles, margins slightly concave; no ventral spine.

Antennular peduncles slender, unarmed; very sparsely setose. Antennal peduncles only slightly shorter than antennular peduncles; fifth segment unarmed; fourth segment with strong distodorsal spine; third with weak distoventral spinule; second with very strong distal dorsolateral and smaller distal dorsomesial spines, and 4 ventrolateral spines; first segment unarmed except for row of minute denticles along distodorsal margin. Antennal acicle reaching base of ultimate peduncular segment; acicle terminating in strong spine with another dorsal to this and row of 5-6 spines extending from distolateral to proximomesial edges of acicle. Scattered long simple and weakly plumose setae on all peduncular segments and acicle. Antennal flagella comprising about 28 articles; ventral setae long and plumose.

Third maxilliped (Figure 2b) with merus unarmed; ischium with very irregular row of 3-4 ventromesial spines; basis with 2 strong ventromesial spines.

Left cheliped (Figure 2c) much larger than right. Dactyl approximately half length of propodus, stout, distinctly flattened laterally, strongly curved, slightly crossing fixed finger at tip; cutting teeth small and rounded, more pronounced at midlength of dactyl. Upper margin with 2 rows of strong tubercles proximally, merging to 1 row distally; sometimes a third very irregular row of smaller tubercles just ventral to these on outer face; remainder of outer face and inner face finely tuberculate; inner face with shallow longitudinal sulcus. Fixed finger short and triangular, not obviously deflexed, cutting teeth most pronounced just proximal to midlength; lower margin with irregular row of blunt tubercles; outer face finely tuberculate with pronounced ridge extending



**Figure 2.** *Diogenes lophochir*. (a)-(f) holotype ♂; (g) paratype ♂. (a) shield and cephalic appendages, dorsal view, setae omitted on left side; (b) basis, ischium and merus of endopod of third maxilliped, mesial view; (c) left cheliped, lateral view; (d) right cheliped, lateral view; (e) second left pereiopod, lateral view; (f) third left pereiopod, lateral view; (g) telson, dorsal view. Scales = 2.0 mm (a, c-f); 1.0 mm (b, g).

proximally almost to point even with dactylar articulation; inner face almost smooth. Palm slightly longer than broad; upper margin with irregular row of broad, curved spines, some smaller spines and tubercles ventral to this; outer face convex and finely tuberculate, with very pronounced, strongly tuberculate crest extending from proximoventral angle parallel with carpal articulation then curving distally along midline of propodus, tubercles diminishing distally and crest terminating quite abruptly at about midlength of palm; lower margin coarsely tuberculate with irregular row of tubercles extending along finger; 1 or 2 small proximal spines or tubercles between medial crest and upper margin; inner surface finely tuberculate, more coarsely near upper and lower margins. Carpus slightly longer than palm, distinctly longer than broad; upper margin with row of strong curved spines, largest distally; outer face with broad area of large tubercles and spines along midline, more finely tuberculate ventral to this but almost smooth between spinose band and upper margin; lower margin with blunt spines and tubercles; inner surface coarsely tuberculate. Merus with upper margin and inner and outer lower margins irregularly spinose and tuberculate; remainder more finely tuberculate. Setae very sparse on dactyl and propodus; longer simple and plumose setae on upper and lower margins of carpus and merus.

Right cheliped (Figure 2d) slightly longer than half length of left. Dactylar length more than half that of propodus; irregular rows of spines along upper margin, diminishing in size distally; cutting teeth small; outer and inner surfaces unarmed, inner surface with deep sulcus. Propodal finger and palm with scattered, irregularly sized spines and tubercles on outer surface; upper edge with larger spines; lower margin with irregular rows of tubercles; inner surface feebly tuberculate. Carpus with upper margin strongly spinose, spines larger distally; outer surface with row of spines medially, smooth between that and upper edge, tuberculate on lower surface, lower margin weakly tuberculate; inner surface feebly tuberculate. Merus longer than carpus; upper margin with row of small spines, larger distally; lower margins weakly spinose; outer surface weakly tuberculate, inner surface almost smooth. All segments more setose than left cheliped, with long simple and weakly plumose setae.

Second pereopods (Figure 2e) slightly longer than left cheliped. Dactyl shallowly recurved, longer than propodus; spines absent; distinct longitudinal sulcus. Propodus about 5 times as long as wide and  $1\frac{1}{4}$  times length of carpus; dorsal margin with irregular row of spines along entire length; dorsolateral surface with some scattered spinules, remainder of surfaces unarmed. Carpus with row of long spines along entire dorsal length; some very small tubercles scattered laterally, remainder smooth. Merus almost as long as propodus and laterally compressed; row of spinules along dorsal edge and some spinules ventrolaterally; otherwise smooth. Segments lightly setose with long setae, mostly simple on distal segments, mostly plumose on merus.

Third pereopods (Figure 2f) slightly longer than second; dactyl more distinctly recurved, propodus slightly more elongate, merus shorter and ischium distinctly longer. Spination similar to second pereopods with row of spines along dorsal margin of propodus and carpus; spines slightly smaller than on second pereopods.

Fourth pereopods with dactyl terminating in weak corneous claw. Rasp occupying more than half length of propodus along ventral margin. Segments unarmed except for single distodorsal spine on carpus; with clumps of long plumose setae.

Males with 4 elongate unpaired uniramous pleopods; pleopods increasing in length from 1 to 3, decreasing slightly to 4. Long finely plumose setae.

Tailfan very asymmetrical, left uropods much larger than right. Telson (Figure 2g) (damaged on holotype) broader than long; left side distinctly produced, weak medial cleft; left posterior lobe with margin denticulate, 12-13 spines larger than remaining spinules; right lobe with 5-6 spines, margin not obviously denticulate. Long simple setae along lateral and posterior margins and scattered in clumps on dorsal surface.

### Etymology

Name derived from the Greek, 'lopho' (crest) and 'chir' (hand), referring to the distinct lateral crest on the left chela (noun in apposition).

### Remarks

*Diogenes lophochir* is known only from two males and a left cheliped. The species resembles *D. costatus*, a species widespread in the Indian Ocean from east Africa to at least India, in possessing a pronounced curved crest on the outer face of the left chela and lacking a crest or row of tubercles ventral to the upper margin of the palm. This pattern distinguishes the two species from *D. rectimanus* Miers, 1884, *D. investigatoris* Alcock, 1905 and *D. bicristimanus* Alcock, 1905.

*D. lophochir* differs from *D. costatus* in the diagnostic characters cited above. In *D. costatus* the antennular peduncles are longer than the antennal, the fixed finger of the left chela is deflexed and the lower margin of this chela is tuberculate only proximally, the carpus of the third pereopods is only weakly spined dorsally and the propodus unarmed.

*D. granulatus* Miers, 1880 was described from Shark Bay, W.A. (Miers 1880; Haswell 1882). This species has only a convex outer surface to the left chela and the fixed finger is very deflexed. *D. guttatus* Henderson, 1888 from Torres Strait does not possess an outer crest on the left chela and has antennal acicles reaching only half the length of the penultimate peduncular segment (Henderson 1888).

### Distribution

Species known only from waters northeast of Rottnest Island, W.A.

### *Diogenes serenei* Forest

*Diogenes serenei* Forest, 1956: 530, figs 12-15; Ball and Haig, 1972: 91; Morgan, 1987b: 176.

#### Material examined

♂, SL 1.9 mm, 3 ♀♀ (all ovig.), SL 3.0 mm, 3.0 mm, 3.0 mm, Swan R. estuary, Fremantle, W.A., 21 December 1972, WAM 24-73.



### Remarks

The specimens examined here agree well with the original description and figures of Forest (1956) and subsequent records (e.g. Ball and Haig 1972; Morgan 1987b). The ventral tooth on the rostral process is well developed.

Specimens inhabited shells of *Velacumantus australis* (Quoy and Gaimard, 1834) and *Cominella eburnea* (Reeve, 1844).

### Distribution

West Indian Ocean, Vietnam, New Guinea, northern and now southwestern Australia.

### *Cancellus* sp.

### Material examined

♂, SL 4.4 mm, west of Garden I., W.A., (32°15'S, 115°06'E), 176-182 m, 18 March 1972, WAM 39-74; ♀, SL 8.3 mm, 40 km west of Jurien Bay, W.A., (30°21'S, 114°38'E), 165 m, 15 February 1976, WAM 796-86.

### Remarks

These specimens differ from the only reported Australian representative of the genus, *C. typus* H. Milne Edwards, 1836, in several characters. The antennular peduncles are longer, the corneas wider and the ocular acicles more spinose than in *C. typus*. On the male, the sixth abdominal segment is very spinose and the coxal segment of the fifth pereopod is very differently shaped from that of *C. typus*. Additionally, the specimens were collected from waters in excess of 165 m depth, while *C. typus* is typically a shallow water species.

These animals do not agree well with descriptions of any of the *Cancellus* species reviewed by Mayo (1973). It is certain that they are undescribed, but until further specimens are obtained it is uncertain if the male and female are conspecific.

### *Clibanarius virescens* (Krauss)

*Pagurus virescens* Krauss, 1843: 56, pl. 4 fig. 3.

*Clibanarius virescens* - Dana, 1852: 466; Dana, 1855: pl. 29 fig. 6a, b; Stimpson, 1858: 235; Alcock, 1905: 159; McCulloch, 1913: 346, pl. 11 fig. 2; Fize and Serène, 1955: 138, fig. 21; Lee, 1969: 43; Morgan, 1987b: 171.

### Material examined

♀, SL 3.7, Geraldton, W.A., littoral, September 1987, WAM 188-88.

### Remarks

The live coloration of Australian representatives of this species is described by McCulloch (1913) and Morgan (1987b).

*Clibanarius virescens* is a very widespread Indo-West Pacific species, inhabiting littoral or very shallow sublittoral rocks and soft substrates. The record from Geraldton is the most southerly for the species on the west coast of Australia.

### Distribution

East Africa, across Indian Ocean to Western Australia, northern and eastern Australia south to Sydney, N.S.W., Lord Howe Island and east to Fiji Islands.

***Trizopagurus strigimanus* (White)**

*Pagurus strigimanus* White, 1847: 121.

*Pagurus aculeatus* H. Milne Edwards, 1848: 62.

*Clibanarius strigimanus* — Miers, 1874: 3, pl. 11 fig. 4; Henderson, 1888: 61; Whitelegge, 1900: 167; McCulloch, 1913: 348; Hale, 1927: 91, fig. 87; Pope, 1947: 131.

*Trizopagurus strigimanus* — Forest, 1952: 6, figs 1, 8, 10, 17; Griffin, 1967: 306, fig. 2; Miyake, 1978: 18.

**Material examined**

3 ♀♀, SL 8.0 mm, 7.3 mm, 7.1 mm, northwest of Bunbury, W.A., (33°00'S, 114°37'E), 219-221 m, 17 March 1972, WAM 1751-86.

**Remarks**

*Trizopagurus strigimanus* is immediately recognisable from all other southwestern Australian hermit crabs by the well developed stridulatory apparatus on the inside face of the carpus and palm of both chelipeds. The species has been comprehensively redescribed and illustrated by Forest (1952) who also discussed relationships of the genus.

Preserved specimens retained deep red pigmentation on the fingers and distal palm of the chelipeds and dactyls of pereopods 2 and 3. Ocular peduncles are similarly red with dorsolateral and dorsomesial white lines and a white area proximoventrally.

The specimens examined here were collected from depths in excess of 200 m, considerably deeper than the 40-80 m depth range cited by Forest (1952).

**Distribution**

Southern Australian endemic, from Sydney region (N.S.W.) south to Vic., S.A. and Tas. Now recorded from southwestern W.A.

***Dardanus arrosor* (Herbst)**

*Cancer arrosor* Herbst, 1796: 170, pl. 43 fig. 1.

*Pagurus striatus* H. Milne Edwards, 1836: 270.

*Pagurus arrosor* - Nobili, 1906: 121; Barnard, 1950: 423, fig. 79, 79a.

*Dardanus arrosor* - Gee, 1925: 159; Hale, 1927: 93, fig. 89; Pope, 1947: 131, fig. 2; Forest, 1955: 90, figs 19, 21; Griffin, 1967: 307; Lee, 1969: 46, fig. 5; Miyake, 1978: 57, pl. 1 fig. 5, text fig. 20.

*Dardanus arrosor arrosor* Forest and de Saint Laurent, 1967: 92, pl. 1 figs 1, 3.

**Material examined**

♂, SL 17.2 mm, Albany area, W.A., from craypot, October 1959, WAM 791-86.

**Remarks**

The one specimen of *D. arrosor* examined agrees well with redescrptions and figures of the species (Hale 1927; Barnard 1950; Forest 1955; Lee 1969; Miyake 1978).

The specimen is assignable to the nominotypical subspecies as presented by Forest and de Saint Laurent (1967).

**Distribution**

Very widespread, from Mediterranean and Red Seas and western Africa, east to Philippines, Taiwan, Japan, New Zealand and Australia. Recorded now from southwestern Australia.

***Dardanus crassimanus* (H. Milne Edwards)**

*Pagurus crassimanus* H. Milne Edwards, 1836: 277; Fize and Serène, 1955: 187.

*Pagurus sculptipes* Stimpson, 1858: 246.

*Pagurus pavimentatus* Hilgendorf, 1878: 816, pl. 3 figs 1-5.

*Clibanarius crassimanus* - Alcock, 1905: 162.

*Dardanus crassimanus* - Buitendijk, 1937: 55; Gordan, 1956: 313; Lee, 1969: 49, fig. 7; Miyake, 1978: 61, fig. 22.

**Material examined**

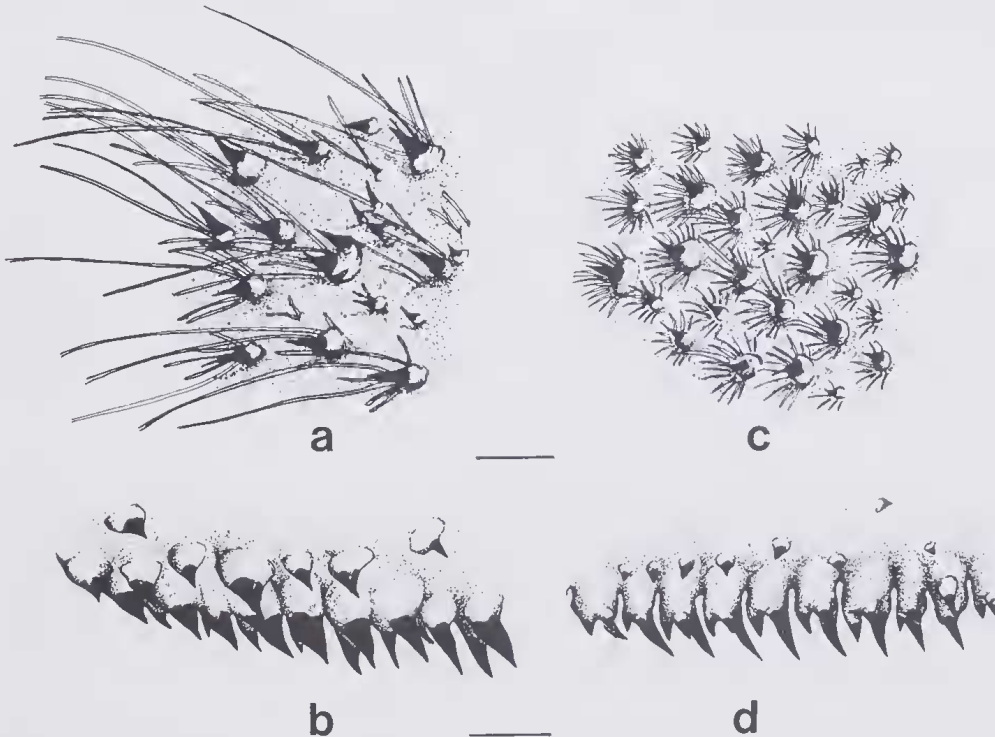
♀, SL 14.5 mm, Parker Point, Rottneest I., W.A., sand and coral, 3 m, 1985, WAM 485-86.

**Coloration** (after 2½ years in alcohol)

Shield red-brown and cream. Ocular peduncles pale purple; ocular acicles brown and cream. Chelipeds red-brown; spines on dactyl, propodus and carpus cream-purple at bases, tips corneous; carpus with large proximodorsal purple patch; merus with purple tubercles. Pereiopods 2 and 3 red-brown with purple tubercles, carpus with large proximodorsal purple patch. Setae yellow.

**Remarks**

The differences between *D. crassimanus* and the very similar *D. setifer* (H. Milne Edwards, 1836) have been discussed by Fize and Serène (1955) and Morgan (1987b). It is



**Figure 3.** a, b, *Dardanus crassimanus*, ♀, SL 14.5 mm, Rottneest Island, WAM 485-86; c, d, *D. setifer*, ♂, SL 9.3 mm, Northern Territory, WAM 164-87. a, c, palm of left chela, lateral view; b, d, lower margin of palm of left chela, mesial view (setae omitted). Scales = 1.0 mm.

certain that confusion between the species has occurred in the literature. *Dardanus setifer* has been identified from northern Australia (Morgan 1987b) but J. Forest (pers. comm.) has suggested that several species might be confused in a *crassimanus-setifer* complex.

The single specimen here identified as *D. crassimanus* conforms to differences between the two species noted by the above authors. The setae on the outer surface of the left chela are longer than in *D. setifer* and not arranged in distinct rosettes around the spines. The lower margin of the left chela is ornamented with two irregular rows of long spines rather than a palissade of usually two lateral and one mesial grouped spines. These differences have not been illustrated previously in a comparative format and are here presented in Figure 3.

No live colour description is available for the Rottneest I. specimen, but on the basis of its preserved colours and the colour notes of Lee (1969) and Miyake (1978), it appears that *D. crassimanus* and *D. setifer* are similarly coloured. It is possible that the ocular peduncles of the former are more distinctly purple but comparison of further specimens is necessary to ascertain this.

*Dardanus crassimanus* has been collected from depths to at least 30 m. The specimen examined here was taken from a shell of *Campanile symbolicum* Iredale, 1917.

### Distribution

East Africa, across Indian Ocean to Sri Lanka, Indonesia, north to Hong Kong, Taiwan and Japan and south to Australia (confirmed on west coast).

### *Dardanus* sp.

#### Material examined

♀, SL 7.7 mm, northwest of Bunbury, W.A., (33°15'S, 114°37'E), 155 m, 17 March 1972, WAM 1752-86; ♂, SL 17.5 mm, off West End, Rottneest I., W.A., 177-183 m, 16 September 1965, WAM 487-86; ♂, SL 19.0 mm, beach at North Fremantle, W.A., 11 April 1972, WAM 76-72; ♂, SL 7.6 mm, northwest of Green Head, W.A., (29°59'S, 114°25'E), 146 m, 22 March 1972, WAM 1754-86; ♀, SL 6.3 mm, west of Lancelin, W.A., (31°00'S, 114°52'E), 146-150 m, 23 March 1972, WAM 1743-86; ♂, SL 8.9 mm, 2 ♀♀, SL 10.8 mm (ovig.), 5.6 mm, southwest of Jurien Bay, W.A., (30°29'S, 114°40'E), 146 m, 9 December 1970, WAM 487-88.

#### Remarks

This species closely resembles *D. hessii* (Miers, 1884) in its subequal chelipeds and their spination. Certain differences between the two species were brought to my attention by J. Forest (pers. comm.), including the more elongate ocular peduncles, more spinose propodus of the third pereopods and greater size of the Western Australian species. Forest correctly regards the two species as distinct and naming of this new species, probably endemic to Australia, awaits his description.

### *Calcinus latens* (Randall)

*Pagurus latens* Randall, 1839: 135.

*Calcinus latens* - Dana, 1852: 459; Dana, 1855: pl. 28 fig. 2; Heller, 1865: 88; Alcock, 1905: 58, pl. 5 fig. 5;



Grant and McCulloch, 1906: 34; Forest, 1951: 84, figs 14-18; Fize and Serène, 1955: 58, fig. 9, pl. 2C; Haig and McLaughlin, 1984: 107; Wooster, 1984: 154.

*Calcinus terrae-reginae* Haswell, 1882: 760; Alcock, 1905: 57, pl. 5 fig. 7.

#### Material examined

3 ♂♂, SL 4.3 mm, 3.8 mm, 3.4 mm, 2 ♀♀, SL 3.9 mm, 3.7 mm, Nancy Cove, Rottnest I., W.A., littoral, 5 April 1986, WAM 208-88; 2 ♀♀, SL 4.1 mm, 3.9 mm, Seven Mile Beach, north of Dongara, W.A., sand and rock, 1 m, 22 April 1986, WAM 207-88.

#### Remarks

*Calcinus latens* is a very widespread littoral and shallow sublittoral species in the Indo-West Pacific. It is most common in areas with live coral such as the Houtman Abrolhos and Shark Bay in Western Australia. The record from just north of Dongara is the southernmost for *C. latens* on the west coast of mainland Australia, but the species also occurs on Rottnest Island near Perth.

In the south of its range on the Western Australian coast, *C. latens* overlaps with *C. dapsiles* sp. nov. The species are distinguished by characters noted for the latter species.

#### Distribution

East Africa, Persian Gulf across Indian Ocean to Indonesia, Philippines, Japan, northern and eastern Australia south to Sydney and now recorded from southwestern Australia, east to Tuamotu and Hawaiian Islands.

### *Calcinus dapsiles* sp. nov.

#### Figure 4

#### Holotype

♂, SL 8.7 mm, CL 14.8 mm, Canal Rocks, (33°41'S, 114°59'E), south of Yallingup, W.A., rocky reef, 2 m, in *Campanile symbolicum* Iredale, 1917 shell, 6 December 1985, WAM 173-88.

#### Paratypes

5 ♂♂, SL 8.0 mm-4.0 mm, 3 ♀♀ (ovig.), SL 4.0 mm, 3.9 mm, 3.8 mm, type locality, WAM 172-88; ♂, SL 3.4 mm, Little Bay in Two Peoples Bay, east of Albany, W.A., rocky reef, 3 m, 18 April 1986, WAM 170-88; ♂, SL 3.8 mm, Ledge Point, King George Sound, east of Albany, W.A., rocks, 2-3 m, 16 April 1986, WAM 171-88; 2 ♂♂, SL 2.8 mm, 2.7 mm, ♀, 4.5 mm, Michaelmas I., King George Sound, east of Albany, W.A., rock and sand, 15-18 m, 16 April 1986, WAM 178-88; 20 specs, SL 5.0 mm-1.9 mm, Frenchmans Bay, old whaling station, south of Albany, W.A., sand and *Posidonia*, 1.5 m, 19 April 1986, WAM 179-88; 2 ♂♂, SL 2.7 mm, 2.1 mm, 2 ♀♀, 3.2 mm, 2.7 mm, Princess Royal Harbour, near Albany, W.A., sand, 3 m, 17 April 1986, WAM 180-88; 13 specs, SL 4.5 mm-1.6 mm (incl. ovig. ♀, SL 2.7 mm), inside Shelter I., west of Albany, W.A., rocks, 1-3 m, 1 December 1985, WAM 181-88; 23 specs, SL 5.1 mm-1.4 mm (incl. 4 ovig. ♀♀, SL 5.1 mm-2.1 mm), Cosy Corner, near Migo I., west of Albany, W.A., rocks and sand, 2-3 m, 1 December 1985, WAM 169-88; 3 ♂♂, SL 3.4 mm, 2.9 mm, 2.5 mm, 2 ♀♀ (ovig.), SL 3.0 mm, 1.7 mm, Prevelly Park, west of Margaret River, W.A., wave cut rock platform, 5 December 1985, WAM 183-88; 4 ♂♂, SL 7.7 mm-3.4 mm, Cottesloe Beach, rock platforms, 2-4 m, 16 January 1986, WAM 190-88; 6 ♂♂, SL 8.4 mm-4.5 mm, 2 ♀♀ (ovig.), SL 6.1 mm, 5.7 mm, west of Burns Beach, Perth, W.A., reef ledges, 20 m, 18 December 1986, WAM 177-88; 6 ♂♂, SL 7.7 mm-4.9 mm, 2 ♀♀, SL 7.5 mm (ovig.), 3.6 mm, 0.5 km north of Little I., off Hillarys Marina, Perth, W.A., 12 December 1985, WAM 176-88; 3 ♂♂, SL 9.2 mm, 8.4 mm, 6.1 mm, Nancy Cove, Rottnest I., W.A., rocks, littoral, 5 April 1986, WAM 192-88; ♂, SL 9.0 mm, Parker Point, Rottnest I., W.A., littoral, January 1987, WAM 194-88; 2 ♂♂, SL 6.4 mm, 4.4 mm, Seven Mile Beach, north of Dongara, W.A., 2 m, sand and seagrass, 22 April 1986, WAM 176-88; 9 specs, SL 4.1 mm-2.0 mm,

Sunday I., Shark Bay, W.A., rocks, 5 m, 14 March 1986, WAM 193-88; ♂, SL 3.4 mm, headland on mainland opposite Cape Ransonnet, Shark Bay, W.A., 12 March 1986, WAM 191-88.

## Diagnosis

A species of *Calcinus* differing from *C. latens* (Randall, 1839) in having dactyls of pereopods 2 and 3 proximally a uniform pink and left posterior lobe of telson with only 1 terminal spine.

## Description

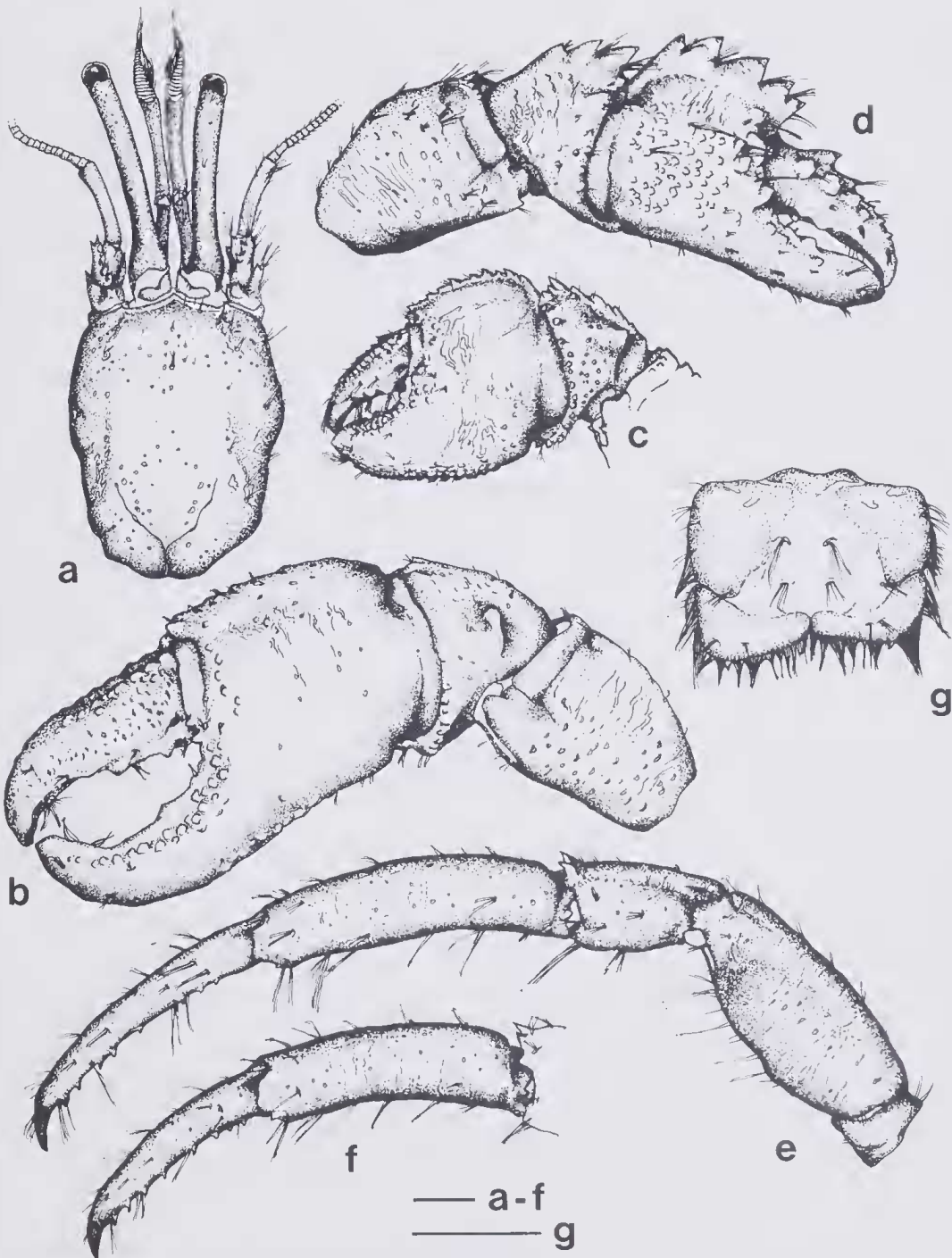
Shield (Figure 4a) 1 1/3 times as long as broad; anterior margin between rostrum and lateral projections shallowly concave, rostrum very produced and obviously exceeding lateral projections. Lateral projections weakly produced, with minute terminal spinules. Dorsal surface of shield lightly punctate, very sparsely setose dorsally and moderately setose laterally.

Ocular peduncles long and slender, slightly shorter than shield but longer than anterior margin of shield, left peduncle longer than right, peduncles inflated proximally; very sparsely setose. Ocular acicles short, distal margin very concave, proximal margin convex; tipped by single spinule (1 paratype with bifid acicles); acicles almost contiguous basally.

Antennular peduncles only slightly shorter than ocular peduncles. Ultimate and penultimate segments unarmed; proximal segment with approximately 6 spinules distolaterally.

Antennal peduncles reaching to distal half of ocular peduncles. Fifth segment unarmed; fourth segment with distodorsal spine; third with distinct distoventral spine and long setae; second segment with distolateral spine usually bifid, sometimes simple, rarely trifid, and mesial spine, sometimes bifid; first segment with dorsolateral and lateral edges unarmed, ventromesial angle with 1 or more spinules. Antennal acicle reaching distal end of penultimate segment of peduncle; terminating in simple or bifid spine; mesial margin with 3-4 spines, distolateral margin with 1 or 2; scattered long setae, especially distally. Antennal flagellum as long as or slightly longer than thorax; minutely setose.

Left cheliped of holotype (Figure 4b) with propodus twice as long as width of palm. Dactyl slightly longer than half length of propodus; cutting edge with several low teeth, largest proximally; outer and upper faces minutely tuberculate, larger tubercles proximally particularly in a dorsolateral row; inner face mostly smooth with some small granules on upper edge. Fixed finger strongly recurved, touching dactyl only at tip, cutting edge with 1 large and several smaller teeth; outer face weakly tuberculate with row of larger tubercles on outer face parallel to cutting edge; lower margin with irregular row of low tubercles. Both fingers almost naked, with only scattered setal clumps, especially distally. Palm as broad as long and compressed laterally; outer surface convex, weakly tuberculate near bases of fingers and on upper surface, upper and lower edges with indistinct row of low tubercles; inner face slightly convex, smooth except for some minute granules and a tubercle at base of setal tuft on lower face. Carpus broad, subtriangular, much shorter than merus, compressed; outer surface almost smooth with



**Figure 4.** *Calcinus dapsiles*. (a)-(b), (d)-(g) holotype ♂, (c) paratype ♀, SL 7.5 mm, WAM 176-88. (a) shield and cephalic appendages, dorsal view, setae omitted on left side; (b) left cheliped of male, lateral view; (c) left cheliped of female, lateral view; (d) right cheliped of male, lateral view; (e) second left pereiopod, lateral view; (f) dactyl and propodus of third left pereiopod, lateral view; (g) telson, dorsal view. Scales = 2.0 mm.

prominent tubercle placed slightly toward upper margin; outer distal margin very finely dentate; upper edge faintly granulate, 1 spine at upper distal angle; inner and lower faces almost smooth, several small denticles on lower distal margin. Merus slightly compressed laterally; outer surface nearly flat, with numerous minute tubercles; lower outer distal angle with 1 or more minute spinules; lower inner distal margin with 3 or more spinules; upper margin with minute tubercles; inner surface flat and smooth.

Females and smaller males with fingers less attenuated and recurved, resulting in less distinct gape. Spines and tubercles better developed especially along upper and lower margins of fingers, upper edge of palm (can be distinctly spinose on females), and upper and lower margins of carpus (Figure 4c).

Right cheliped of holotype (Figure 4d) with propodal length approximately  $2/3$  length of left propodus. Dactyl about half length of propodus; upper margin with 2 irregular rows of large acute corneous-tipped spines, diminishing in size distally; inner surface with some scattered spines; cutting edge with about 2 proximal teeth. Fixed finger touching dactyl only at tip; lower margin tuberculate; outer face granular with row of tubercles parallel to cutting edge; inner face weakly granulate; cutting edge with about 3 small teeth. Palm broader than long, with outer surface convex and with low tubercles and 3 large spines in row proximal to articulation of dactyl; upper margin produced as crest with 5 very large corneous-tipped spines and 1-2 spines ventral to these; lower edge with blunt tubercles; inner face flat and almost smooth; palm with tufts of setae especially along upper and outer faces. Carpus broad, much shorter than merus, compressed; outer face with minute granulations; outer distal edge finely dentate; upper edge with 3 spines; inner face almost smooth, flattened; inner distal margin unarmed or with blunt spine near lower distal angle; setae sparse on carpus. Merus slightly compressed, outer surface slightly convex, nearly smooth except for low tubercles; upper edge and distal outer margin with minute tubercles; 1 spine on lower distal margin; inner surface smooth, flat; lower margin with some minute tubercles; tufts of sparse setae especially on upper and lower edges.

Sexual and allometric differences less significant in right cheliped than in left.

Second pereiopods (Figure 4e) much longer than left cheliped, left and right pereiopods of similar length. Dactyl as long as propodus, more elongate on large specimens, terminating in strong claw; ventral margin with row of 6-8 short corneous spines; scattered, sparse clumps of long simple setae, longer ventrally. Propodus unarmed except for minute spinule distodorsally and 1-2 spinules distoventrally; setation like that of dactyl. Carpus with large spine at distodorsal angle and usually 1-2 small spines lateral to it, sometimes a second dorsal spine; scattered setae, longer ventrally. Merus compressed; 1 spine at distal ventrolateral angle; long simple setae dorsally and ventrally.

Third pereiopods (Figure 4f) shorter than second, primarily due to shorter, stouter dactyl and propodus. Spinination on third pereiopods similar to that of second pereiopods. Setation slightly heavier on carpus and merus than on pereiopod 2.

Sternite of pereiopod 3 with anterior lobe broad and subrectangular, with rounded lateral projections; heavily setose.



Fifth abdominal segment with numerous minute spinules on dorsal surface. Telson (Figure 4g) with left posterior lobe slightly larger than right, size difference more evident on small specimens; both lobes armed with posterior spine offset ventrally, lateral margins unarmed; margins with fringe of long setae.

### Coloration (in life)

Shield brown or salmon-brown of variable shades, often paler posteriorly. Ocular peduncles pale brown, usually with pink tinge proximodorsally and thin cream band at base of corneas; ocular acicles pale brown; corneas black. Antennular and antennal peduncles brown and cream; antennular flagella cream with orange ventrally, antennal flagella pale orange. Chelipeds with fingers cream or white with small scattered red or orange spots; palm mostly chocolate brown, usually cream distally; carpus chocolate brown with white on spines and tubercles; merus similar to carpus but usually paler. Pereiopods 2 and 3 with dactyl white or cream for distal 1/3 to 1/2, proximal 1/2 to 2/3 pink; propodus white on distal margin, remainder red, chocolate brown or purple-brown, usually red proximally; carpus brown or purple-brown, paler (sometimes cream) near articulations; merus similar to carpus but paler. All pereiopod segments with scattered small red or orange spots, usually at setal pores. Pereiopods 4 and 5 pale cream or orange, with red spots. Small juveniles much paler, sometimes entirely cream or white except for pale brown on ocular peduncles, pale orange or brown on antennules and antennae, and pale orange or pink proximally on dactyl and propodus of pereiopods 2 and 3. Orange spots on chelipeds and pereiopods 2 and 3 relatively larger than on large specimens.

### Etymology

From the Greek 'dapsiles' meaning 'abundant'.

### Remarks

*Calcinus dapsiles* is the most abundant and ubiquitous of the shallow water hermit crabs in southwestern Australia, where for most of its range it is the sole representative of its genus. It occurs in a variety of habitats, including rocky reefs, soft sand and shell rubble, seagrass beds and coral reefs. The species inhabits a very wide range of gastropod shells, probably reflecting the most readily available shells in any area and the size of the crab. Gastropods utilised by type specimens are *Campanile symbolicum* Iredale, 1917, *Thais orbita* (Gmelin, 1791), *Turbo torquatus* Gmelin, 1790, *Thalotia conica* (Gray, 1827), *Cominella eburnea* (Reeve, 1846), *Bittium granarium* (Kiener, 1842), *Lepsiella flindersi* (A. Adams and Angas, 1864), *Nassarius pyrrhus* (Menke, 1843), *Astraliu squamifera* (Koch, 1844), *A. tentorium* (Thiele, 1930), *Phasianella australis* (Gmelin, 1788), *Mitra carbonaria* Swainson, 1822, *Clanculus maxillatus* (Menke, 1843), *Prothalotia lehmanii* (Menke, 1843), *Rhinoclavis biterberculatum* (Sowerby, 1855), *Conus anemone* (Lamarck, 1810) and *Drupella* sp.

Ovigerous females have been collected in December and January. Females may be berried at shield lengths as small as 1.7 mm. *C. dapsiles* can be readily recognised in the field by its distinctive red and white colour patterns, together with the small reddish spots on the chelipeds and walking legs.

The species most closely resembles *C. latens*, a widespread species of the Indo-West Pacific, which co-occurs with *C. dapsiles* in the north of the latter's range (e.g. Dongara, Houtman Abrolhos, Shark Bay). The two species can be easily distinguished on the basis of coloration. The dactyls of pereiopods 2 and 3 have short proximal longitudinal stripes of dark red-blue on a pink background in *C. latens*, while those of *C. dapsiles* are proximally a uniform pink. As discussed by Haig and McLaughlin (1984), some authors have described the proximal dactyl colour of *C. latens* as uniform (e.g. Edmondson 1946; Wooster 1984). It is probable that all specimens of *C. latens* do display the short longitudinal dark stripes on the dactyl of pereiopods, but if in fact some populations are uniform in coloration, then *C. dapsiles* can still be distinguished by the scattered red spots on the chelipeds and pereiopods. Morphologically, the species are similar in their possession of simple ocular acicles, a single marginal spine on the right posterior lobe of the telson (though some specimens of *C. latens* I have examined have 2 spines) and in the lack of a setal brush on the third left pereiopod. They can be distinguished by the more numerous marginal spines on the left posterior lobe of the telson of *C. latens*.

### Distribution

Southwestern Australian endemic, from east of Albany north and west to Shark Bay, W.A.

### Paguridae *Pagurus sinuatus* (Stimpson)

*Eupagurus sinuatus* Stimpson, 1858: 250; Haswell, 1882: 153; Pope, 1947: 131, fig. 2; Dakin *et al.*, 1952: 199, pl. 44 figs 3, 5.

*Pagurus sinuatus* — Gordan, 1956: 335; Griffin, 1967: 306, fig. 4; Lewinsohn, 1969: 63; Healy and Yaldwyn, 1970: 72, pl. 33.

### Material examined

♂, SL 9.6 mm, ♀, SL 5.5 mm, Bremer Bay, W.A., 2 m, 29 November 1985, WAM 292-88; ♀, SL 8.8 mm, Cheyne Beach, east of Albany, W.A., *Posidonia* and *Heterozostera* flat, 2 February 1966, WAM 840-86; 4 ♂♂, SL 9.7 mm-4.9 mm, 2 ♀♀, SL 5.4 mm (ovig.), 3.8 mm, Little Bay in Two Peoples Bay, east of Albany, W.A., granite rocks, 3 m, 2 December 1985, WAM 293-88; 10 specs, SL 11.8 mm-3.0 mm, Little Bay, W.A., rocks, 5-12 m, 18 April 1986, WAM 294-88; ♂, SL 11.1 mm, ♀, SL 12.3 mm, Michaelmas Island, east of Albany, W.A., rocks, 15-18 m, 16 April 1986, WAM 295-88; ♂, SL 13.1 mm, 4 ♀♀, SL 14.1 mm-3.8 mm (incl. ovig. ♀, SL 8.4 mm), Jimmy Newells Harbour, south of Albany, W.A., rocks and sand, 1-2 m, 19 April 1986, WAM 296-88; ♂, SL 10.9 mm, Frenchmans Bay, old whaling station, south of Albany, W.A., rocks near seagrass, 1.5 m, 19 April 1986, WAM 297-88; ♀ (ovig.), SL 7.4 mm, Albany, W.A., January 1988, WAM 154-88; 4 ♂♂, SL 13.3 mm-4.8 mm, 2 ♀♀ (ovig.), SL 8.6 mm, 6.1 mm, inside Shelter Island, west of Albany W.A., 1-2 m, 1 December 1985, WAM 298-88; ♂, SL 11.1 mm, 2 ♀♀, SL 9.4 mm (ovig.), 6.5 mm, Cosy Corner, west of Albany, W.A., 1 December 1985, WAM 299-88; 10 specs, SL 14.6 mm-2.5 mm, Ocean Beach, south of Denmark, W.A., rocks, 1 m, 4 December 1985, WAM 300-88; ♀, SL 6.3 mm, Parry Beach, west of Denmark, W.A., rocks, 2 m, 4 December 1985, WAM 301-88; ♂, SL 14.5 mm, ♀ (ovig.), SL 13.2 mm, Cowaramup Bay, south of Yallingup, W.A., 30 October 1966, WAM 482-88; ♂, SL 9.1 mm, ♀ (ovig.), SL 6.3 mm, Canal Rocks, south of Yallingup, W.A., rocks, 2 m, 6 December 1985, WAM 302-88; ♂, SL 10.4 mm, 2 ♀♀, SL 12.3 mm, 4.8 mm, Geordie Bay, Rottneet I., 18 December 1985, WAM 495-86; ♂, SL 6.1 mm, Cervantes, W.A., outer reef, 4 May 1987, WAM 303-88; 2 ♀♀, SL 13.8 mm, 7.7 mm, Big Wave Reef, off Cervantes, W.A., coral slab on sand, 12 m, 6 April 1987, WAM 348-88, 349-88.

### Coloration (in life)

Shield pale orange and red with darker red-violet mottling and patches. Ocular peduncles pale pink or cream, with band of orange at midlength and thinner areas of orange at distal and proximal margins; acicles pale orange or pink. Antennular peduncles with orange band on proximal half of penultimate segment and broader proximal orange or red band on ultimate segment; flagella orange. Antennal peduncles cream and orange; flagella orange. Chelipeds with dactyl orange or orange-violet, finger tip cream or cream-violet; propodus red-orange, paler distally on palm and on finger; finger tip cream or cream-violet; carpus and merus orange or orange-red, sometimes almost burgundy. Spines and tubercles on chelipeds paler, often cream, especially pale on carpus and merus. Pereiopods 2 and 3 distinctly banded; dactyl violet distally especially mesially and laterally, dorsal and ventral edges more strongly orange; propodus and carpus with red or maroon band at midlength, pale violet distal and proximal to this and orange near articulations; band more diffuse on merus, generally mottled orange, red and violet. Setae orange and red.

### Remarks

*Pagurus sinuatus* closely resembles *P. hirtimanus* Miers, 1880, a widespread species occurring from the Red Sea across the Indian Ocean to Indonesia, Malaysia, Philippines, Japan, New Guinea and the Fiji Islands. De Man (1890) suggested that the two species may be synonymous. Lewinsohn (1969) discussed the differences between *P. hirtimanus* and *P. sinuatus* and concluded that specific recognition of the two was warranted, a decision with which I concur. Lewinsohn's diagnostic characters require some qualification however. In this I have compared a specimen definitely identifiable as *P. hirtimanus*, recently collected from near Madang, Papua New Guinea (WAM 451-88), with the material of *P. sinuatus*.

Lewinsohn correctly noted that in *P. hirtimanus* the corneas are distinctly more swollen, pereiopods 2 and 3 lack plumose setae present on *P. sinuatus*, the right cheliped has longer setae (in fact, the setae on *P. sinuatus* are plumose while simple on *P. hirtimanus*) and the distolateral margin of the merus of the right cheliped is less spinose. In the last instance, Lewinsohn described the margin of the merus of *P. hirtimanus* as 'glatt oder nur leicht gekerbt' and that of *P. sinuatus* as having 'deutliche Zähne'. On the specimens here examined, the margin of *P. hirtimanus* bears small but distinct spinules and that of *P. sinuatus*, large spines.

In one character, Lewinsohn appears to be notably incorrect. He recorded that the rostrum of *P. hirtimanus* has a distinct point, while that of *P. sinuatus* is 'abgerundet und trägt ... keine deutliche Spitze'. On all specimens of *P. sinuatus* examined here, the rostrum is acutely triangular and bears a distinct terminal spinule, if anything rather more pronounced than on the specimen of *P. hirtimanus*. In his original description, Stimpson (1958) noted the rostrum of *P. sinuatus* as 'acutus prominens'.

*P. sinuatus* is a large hermit crab, common in shallow sublittoral waters of southern Western Australia in rocky areas where wave and surge action are quite strong. It is less commonly found in sheltered habitats and is rarely collected from soft sediments and

seagrass beds (e.g. WAM 840-86). The species is very active when disturbed, preferring to run from danger rather than to retreat into the shell. When collected, specimens commonly vacate their shell and scuttle, naked, from their attacker.

The species appears to prefer globose, relatively voluminous shells. Specimens examined inhabited shells of *Turbo torquatus* Gmelin, 1790, *Phasianella ventricosa* Swainson, 1822, *Thais orbita* (Gmelin, 1791), *Bulla quoyii* Gray, 1843, *Cominella eburnea* (Reeve, 1846), *Campanile symbolicum* Iredale, 1917, *Phasianotrochus eximius* (Perry, 1811), *Lyria mitraeformis* (Lamarck, 1811), *Littorina unifasciata* Gray, 1826 and a bursid sp.

### Distribution

A southern Australian endemic species, from the Sydney region, N.S.W., west to Western Australia as far north as Shark Bay. (No confirmed records from Vic., Tas. or S.A. but probably occurring in at least the mainland states.)

### *Pagurixus jerviensis* McLaughlin and Haig

*Eupagurus lacertosus* - Pope, 1947: 131, fig. 3; Dakin *et al.*, 1948: 209; Dakin *et al.*, 1952: 199, pl. 44 fig. 7. (Not *E. lacertosus* Henderson, 1888).

*Pagurus lacertosus* - Griffin, 1967: 306; Healy and Yaldwyn, 1970: 72, fig. 35. (Not *P. lacertosus* (Henderson, 1888)).

*Pagurixus jerviensis* McLaughlin and Haig, 1984: 139, fig. 6.

### Material examined

2 ♂♂, SL 2.4 mm, 1.7 mm, ♀, SL 1.8 mm, Little Bay in Two Peoples Bay, east of Albany, W.A., 2-10 m, 18 April 1986, WAM 350-88; ♂, SL 1.8 mm, Two Peoples Bay, picnic area, near *Posidonia*, 2 m, 18 April 1986, WAM 352-88; 2 ♂♂, SL 2.9 mm, 1.9 mm, ♀ (ovig.), SL 2.0 mm, Frenchmans Bay, old whaling station, 19 April 1986, WAM 353-88; ♂, SL 2.5 mm, Jimmy Newells Harbour, south of Albany, W.A., rocks, 1-2 m, 19 April 1986, WAM 351-88.

### Remarks

The Western Australian specimens examined here agree well with the description and figure of the species by McLaughlin and Haig (1984). On these specimens, the spines along the ventral margin of the dactyl of pereopods 2 and 3 number 7-9, usually 8. The median cleft in the telson can be slightly deeper than that illustrated by McLaughlin and Haig.

*Pagurixus jerviensis* is a small, active hermit crab, usually found under rocks or amongst shell debris in shallow sublittoral waters. It has frequently been confused with *Lophopagurus lacertosus* (Henderson, 1888) in the eastern states of Australia (e.g. Pope 1947; Dakin *et al.* 1948; Dakin *et al.* 1952; Griffin 1967; Healy and Yaldwyn 1970). For a discussion of this confusion and of the relationships of *P. jerviensis*, see McLaughlin and Haig (1984).

In Western Australia, the species has been collected from shells of *Phasianella australis* (Gmelin, 1788) and *Dentimitrella semiconvexa* (Lamarck, 1822).



## Distribution

Southeastern Australia at least as far north as Sydney, N.S.W., Lord Howe Island; now recorded from southwestern Australia.

## Discussion

Of the 17 species of hermit crab here recorded from southwestern Australia, 11 (65%) appear to be endemic to southern Australia from approximately the mid-coast of New South Wales to Shark Bay in Western Australia. Of these, five species (*Paguristes longisetosus*, *P. purpureantennatus*, *Diogenes lophochir*, *Calcinus dapsiles* and *Cancellus* sp.) are presently known only from southwestern Australia. Five of the remaining species (29% of total species) are widely distributed in the Indo-West Pacific and one, *Dardanus arrosor*, is even more widespread. Four of these species occur in the north of the area discussed in this paper (i.e. near Geraldton) or near Rottnest Island, where the Leeuwin Current results in warmer water conditions and greater transfer of tropical larvae than occurs at equivalent latitudes on the mainland of Western Australia (Hodgkin and Phillips 1969; Cresswell and Golding 1980; Maxwell and Cresswell 1981). Preliminary collection by the author has revealed the Houtman Abrolhos Islands to be similarly better endowed in tropical species of hermits than are the mainland waters of Geraldton.

## Acknowledgements

I thank Dr J. Forest for drawing my attention to the undescribed species of *Dardanus*. Dr Forest and an anonymous referee critically reviewed the manuscript.

## References

- Alcock, A. (1905). *Catalogue of the Indian decapod Crustacea in the collection of the Indian Museum. Part II. Anomura. Fasciculus I. Pagurides*. pp. i-xi, 1-197, pls 1-16 (Indian Museum, Calcutta.)
- Baker, W.H. (1905). Notes on South Australian decapod Crustacea. Part III. *Trans. R. Soc. S. Aust.* **29**: 252-269.
- Ball, E.E. Jr. and Haig, J. (1972). Hermit crabs from eastern New Guinea. *Pacific Sci.* **26**: 87-107.
- Barnard, K.H. (1950). Descriptive catalogue of South African decapod Crustacea (crabs and shrimps). *Ann. S. Afr. Mus.* **38**: 1-837.
- Black, R. and Prince, J. (1983). Fauna associated with the coral *Pocillopora damicornis* at the southern limit of its distribution in Western Australia. *J. Biogeog.* **10**: 135-152.
- Buitendijk, A.M. (1937). Biological results of the Snellius Expedition. IV. The Paguridea of the Snellius Expedition. *Temminckia* **2**: 251-280.
- Cresswell, G.R. and Golding, T.J. (1980). Observations of a south-flowing current in the southeastern Indian Ocean. *Deep-Sea Res.* **27A**: 449-466.
- Dakin, W.J., Bennett, I. and Pope, E.C. (1948). A study of certain aspects of the ecology of the intertidal zone of the New South Wales coast. *Aust. J. Sci. Res. Ser B.* **1**: 176-230.
- Dakin, W.J., Bennett, I. and Pope, E.C. (1952). *Australian Seashores*. (Angus and Robertson, Sydney.)

- Dana, J.D. (1852). Crustacea. *United States Exploring Expedition during the years 1838-42 under the command of Charles Wilkes, U.S.N.* 13(1): i-viii, 1-685. (C. Sherman, Philadelphia.)
- Dana, J.D. (1855). Crustacea. *United States Exploring Expedition during the years 1838-42 under the command of Charles Wilkes, U.S.N.* 13 (Atlas): 1-27, 96 pls.
- Edmondson, C.H. (1946). Reef and shore fauna of Hawaii. *Bishop Mus. Spec. Publ.* 22: 1-381.
- Fize, A. and Serène, R. (1955). Les Pagures du Vietnam. *Inst. Oceanogr., Nhatr.* 45: i-ix, 1-228.
- Forest, J. (1951). Remarques sur quelques Paguridae du genre *Calcinus* à propos de la description de deux espèces nouvelles de Polynésie orientale: *Calcinus seurati* et *Calcinus spicatus*. *Bull. Soc. Zool. France* 76(1-2): 83-99.
- Forest, J. (1952). Contributions a la revision des Crustaces Paguridae. I. Le genre *Trizopagurus*. *Mem. Mus. Nat. Hist. nat.* (Ser. A.) 5(1): 1-40.
- Forest, J. (1955). Crustacés Décapodes, Pagurides. *Expédition océanographique belge dans les eaux côtières africaines de l'Atlantique sud (1948-1949)*. *Res. Sci.* 3(4): 21-147.
- Forest, J. (1956). Les Pagures du Viet-Nam. I. Le genre *Diogenes* Dana. *Bull. Mus. Nat. Hist. nat.* (Ser. 2.) 28(6): 524-532.
- Forest, J. and de Saint Laurent, M. (1967). Campagne de la Calypso au large des cotes atlantiques de l'Amérique du sud (1961-1962). 6. Crustacés Décapodes: Pagurides. *Ann. Inst. Oceanogr.* 44: 125-172.
- Gee, N.G. (1925). Tentative list of Chinese decapod Crustacea. *Lignaam Agric. Rev. Canton* 3(2): 151-166.
- Gordan, J. (1956). A bibliography of pagurid crabs, exclusive of Alcock, 1905. *Bull. Am. Mus. Nat. Hist.* 108: 253-352.
- Grant, F.E. and McCulloch, A.R. (1906). On a collection of Crustacea from the Port Curtis district, Queensland. *Proc. Linn. Soc. N.S.W.* 31: 2-53.
- Griffin, D.J.G. (1967). Hermit crabs. *Aust. Nat. Hist.* 15(10): 305-309.
- Haig, J. and McLaughlin, P.A. (1984). New *Calcinus* species (Decapoda: Anomura: Diogenidae) from Hawaii, with a key to the local species. *Micronesica* 19(1-2): 107-121.
- Hale, H.M. (1927). *The Crustaceans of South Australia*. Part I. (British Science Guild and South Australian Government, Adelaide.)
- Haswell, W.A. (1882). *Catalogue of the Australian Stalk - and Sessile-eyed Crustacea*. (Australian Museum, Sydney.)
- Healy, A. and Yaldwyn, J. (1970). *Australian Crustaceans in Colour*. (A.H. and A.W. Reed, Sydney.)
- Heller, C. (1865). Crustaceen. In: *Reise der oesterreichischen Fregatte Novara um die Erde in den Jahren 1857-59 unter den Befehlen des Commodore B. von Wullerstorf-Urbair*. Zoologischer Theil 2(3): 1-280. (Kaiserlich-königlichen Hof-und Staatsdruckerei, Wien.)
- Henderson, J.R. (1888). Report on the Anomura collected by H.M.S. Challenger during the years 1873-76. *Rep. Zool. Challenger Exp.* 27: i-xi, 1-221.
- Herbst, J.F.W. (1791-1796). Versuch einer Naturgeschichte der Krabben und Krebse 2: i-viii, 1-225 (Berlin and Stralsund.)
- Hilgendorf, F. (1878). Die von Herrn Peters in Mocambique gesammelten Crustaceen, bearbeitet von Herrn Dr. F. Hilgendorf. *Monatsberichte der königlich preussischen Akademie der Wissenschaften zu Berlin* 1878 (1879): 782-851.
- Hodgkin, E.P. and Phillips, B.F. (1969). Sea temperatures on the coast of southwestern Australia. *J. R. Soc. West. Aust.* 52 (2): 59-62.
- Krauss, F. (1843). Die Sudafricanischen Crustaceen. Eine Zusammenstellung aller bekannten Malacostraca. Bemerkung über deren Lebensweise und geographische Verbreitung, nebst Beschreibung und Abbildung mehrerer neuen Arten: 1-68. (E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart.)
- Lee, S.-C. (1969). Anomuran crustaceans of Taiwan. Part I. Diogenidae. *Bull. Inst. Zool., Acad. Sin.* 8: 39-57.
- Lewinsohn, Ch. (1969). Die Anomuren des Roten Meeres (Crustacea Decapoda: Paguridea, Galatheaidea, Hippidea). *Zool. Verhandl. Leiden* 104: 1-213.

- Man, J.G. de. (1890). Carcinological studies in the Leyden Museum. No. 4. *Notes Leyden Mus.* 12(13): 49-126.
- Maxwell, J.G.H. and Cresswell, G.R. (1981). Dispersal of tropical marine fauna to the Great Australian Bight by the Leeuwin Current. *Aust. J. mar. Freshw. Res.* 32: 493-500.
- Mayo, B.S. (1973). A review of the genus *Cancellus* (Crustacea: Diogenidae) with the description of a new species from the Caribbean Sea. *Smithsonian Contrib. Zool.* 150: 1-63.
- McCulloch, A.R. (1913). Studies in Australian Crustacea. No. 3. *Rec. Aust. Mus.* 9: 321-353.
- McLaughlin, P.A. and Haig, J. (1984). A review of *Pagurixus* (Decapoda, Anomura, Paguridae) and descriptions of new species. *Crustaceana* 47(2): 121-148.
- Miers, E.J. (1874). Zool. Erebus and Terror, *Crust.* 1-5 (London.)
- Miers, E.J. (1880). On a collection of Crustacea made by Baron Herman - Maltzan at Goree Island, Senegambia. *Ann. Mag. Nat. Hist.* (5) 8: 204-220, 259-281, 364-377.
- Milne Edwards, H. (1836). Observations zoologiques sur les Pagures et description d'un nouveau genre de la tribu des Paguriens. *Ann. Sci. nat. Zool.* (Ser. 2) 6: 257-288.
- Milne Edwards, H. (1848). Note sur quelques nouvelles espèces du genre Pagure. *Ann. Sci. nat. Zool.* (Ser. 3) 10: 59-64.
- Miyake, S. (1978). *The Crustacean Anomura of Sagami Bay*. (Biological Laboratory, Imperial Household, Tokyo.)
- Montgomery, S.K. (1931). Report on the Crustacea Brachyura of the Percy Sladen Trust Expedition to the Abrolhos Islands under the leadership of Professor W.J. Dakin, D.Sc., F.L.S., in 1913; along with other crabs from Western Australia. *J. Linn. Soc. Lond.* 37: 405-465.
- Morgan, G.J. (1987a). Two new species of *Paguristes* (Decapoda: Anomura: Diogenidae) from southwestern Australia. *Proc. Biol. Soc. Wash.* 100(4): 726-734.
- Morgan, G.J. (1987b). Hermit crabs (Decapoda, Anomura: Coenobitidae, Diogenidae, Paguridae) of Darwin and Port Essington, northern Australia. *The Beagle, Rec. N.T. Mus.* 4(1): 165-186.
- Morgan, G.J. (1987c). Abbreviated development in *Paguristes frontalis* (Milne Edwards, 1836) (Anomura: Diogenidae) from southern Australia. *J. Crust. Biol.* 7(3): 536-540.
- Mower, A.G.J. and Shepherd, S.A. (1988). The crab fauna of West Island, South Australia: their abundance, diet and role as predators of abalone. *Trans. R. Soc. S. Aust.* 112(2): 83-86.
- Nobili, G. (1906). Faune carcinologique de la Mer Rouge. Décapodes et Stomatopodes. *Ann. Sci. nat. Zool.* (Ser. 9) 4: 1-347.
- Phillips, D.A.B., Handrech, C.P., Boch, P.E., Burn, R., Smith, B.J. and Staples, D.A. (eds) (1984). *Coastal Invertebrates of Victoria. An Atlas of Selected Species*. (Marine Research Group of Victoria and Museum of Victoria, Melbourne.)
- Pope, E.C. (1947). The endless house-hunt. *Aust. Mus. Mag.* 9(4): 129-132.
- Randall, J.W. (1839). Catalogue of the Crustacea brought by Thomas Nuttall and J.K. Townsend, from the west coast of North America and the Sandwich Islands. *J. Acad. nat. Sci. Philad.* 8: 106-147.
- Stimpson, W. (1858). Prodromus descriptionis animalium evertibratorum, quae in Expeditione ad Oceanum Pacificum Septentrionalem . . . Pars VII. Crustacea Anomura. *Proc. Acad. nat. Sci. Philad.* 10: 225-252.
- White, A. (1847). Descriptions of new or little-known Crustacea in the collection of the British Museum. *Proc. Zool. Soc. Lond.* 15: 118-126.
- Whitelegge, T. (1900). Crustacea. Part 1. Scientific results of the trawling expedition of H.M.C.S. 'Thetis', off the coast of New South Wales, in February and March, 1898. Part 2. *Aust. Mus. Mem.* 4: 135-199.
- Wooster, D.S. (1984). The genus *Calcinus* (Paguridea, Diogenidae) from the Mariana Islands including three new species. *Micronesica* 18(2): 121-162.